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SCIENTIFIC PAPERS.

A STUDY OF THE VENATION OF THE SPECIES OF SALIX DESCRIBED IN GRAY'S MANUAL, WITH REFERENCE TO THEIR DETERMINATION.

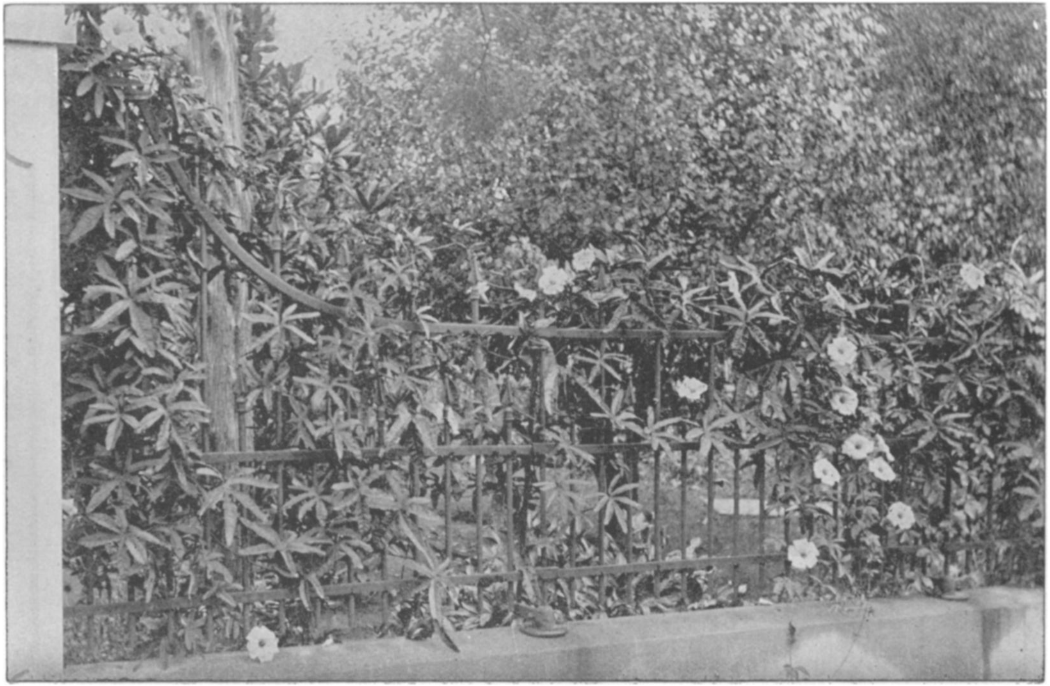
BY N. M. GLATFELTER, M. D.

INTRODUCTION.

I am not aware that any attempt has been made, heretofore, at distinguishing the species of Salix by their veining alone. That the accomplishment of this object is desirable will readily be granted. We distinguish the faces of individuals, or family characteristics, without being able, easily, to point out the particulars causing the different impressions. An experienced eye will distinguish even at a distance, an oak, an elm, or a cherry tree, or one kind of oak from another, by its form as produced by the special mode, in each case, of the distribution of the branches. It is believed that a careful study of the venation of willows will be a means, at least equally decisive in arriving at results; for the differences in their venation, though on a smaller scale, are, I think, equally striking. Should the following descriptions not always be sufficiently clear and definite, there will still remain the impression produced in each particular case, upon the force of which I would insist.

A glance at the accompanying plates will show the wide variety of venation. That no difficulties present themselves, by this method, is not claimed. At two or three points where certain species approach each other with extreme closeness, the determination dependent wholly upon the method, might, in single instances, fail, even in the hands of an expert. For, besides this similarity between certain species, there is often considerable variation in the

Reprints issued Oct. 5, 1893.



IPOMOEA PANICULATA.

same species, especially if age is not regarded. The method is, therefore, not submitted as altogether complete in itself, but as supplemental, and, it is hoped, a useful aid to the usual technical descriptions of the species in the works on the subject.

With regard to the variation referred to above, it is chiefly dependent upon the age of the leaf, but partly also upon the season. Leaves early in the season, though of full size, generally lack character, that is certain characteristic features are not well developed. Thin-veined leaves, as might be expected, show obliteration sooner than their opposites.

It was not easy to find a basis upon which any sort of grouping might be founded. The best that seemed feasible was by taking the character of the *secondaries* as a guide. Inasmuch as the *primaries* are regular almost without exception, they would not serve the purpose. I found that if the secondaries be regular, there will be the impression of regular veining; and that the more irregular they are, the greater the impression of irregularity.

Building upon this basis I was enabled to put the included species into three fairly well defined groups. The first, comprising regular veined leaves, embraces S. alba, S. fragilis, S. lucida, S. phylicifolia, and S. argyrocarpa. The second, exhibiting partly irregular veining, consists of those species in which the secondaries, though often quite regular, sometimes lapse into marked irregularity. This group embraces S. nigra, S. amygdaloides, S. adenophylla, S. discolor, S. cordata, S. sericea, S. petiolaris, S. myrtilloides, and S. candida. Lastly, the third group comprises those species which have their secondaries almost invariably irregular, resulting in an impression of great and general irregularity of veining. In this group come S. humilis, S. tristis, S. rostrata, S. glaucophylla, S. balsamifera, S. purpurea, S. Babylonica, S. longifolia, S. herbacea, and S. Uva Ursi. S. viminalis, at the suggestion of the distinguished salicologist, M. S. Bebb, Esq., was left off of the list.

Besides the foregoing grouping, the species have been arranged as nearly as possible (it is believed with some degree of success) in the order of their resemblances. We may then distinguish sub-groups such as the following: *a*, S. alba, fragilis and lucida; *b*, phylicifolia and argyrocarpa; *c*, nigra and amygdaloides; *d*, adenophylla, discolor, cordata, petiolaris, sericea, myrtilloides, and, more distantly, candida; *e*, humilis and tristis; *f*, rostrata, glaucophylla, and balsamifera. Each of the remaining species, viz.: S. purpurea, Babylonica, longifolia, herbacea, and Uva Ursi, may be regarded as unique.

The illustrations are direct photographic copies from the natural leaves by means of transmitted light, reproduced in print by the artotypist. In spite of a reasonable amount of patience and effort it will be noticed there are considerable defects. The inherent difficulties in rendering some of the leaves were too great to be overcome. In selecting leaves for the plates from samples, regard was shown for those which should best exhibit the principal venation characteristics, although others might promise better results as to mechanical execution, or make finer pictures, or even present a more characteristic outline.

The reader is cautioned against supposing the representations to present complete and perfect pictures of what may be seen by transmitted light in the natural leaves. The very minute details, which all help to make up the impression, are, generally, more or less wanting. Even though at the first, the print was quite complete as to minutiae, something of its definiteness was lost at every step of the successive manipulations; so that wherever the natural leaf is available, it is to be regarded as far preferable for study. In reference to the terms employed in the descriptions, need was felt for some not ordinarily used in botanical descriptions. As definite a meaning as possible was given to each one used, and such meaning assigned to each as will be found defined in the accompanying glossary. The terms " loop " and " arch," so much used, were found very convenient, and no other more suitable substitutes could be thought of.

I desire here to make general acknowledgment of my great obligation to all my correspondents who so kindly forwarded to me, at request, the fresh material needed for my work. Credit is given to each one respectively in the synopsis.

GLOSSARY.

Primaries and secondaries, as generally used.

Tertiaries, the veinlets next after secondaries, used in subdividing.

Costals, the short or incomplete primaries.

Terminals, the delicate veining within the final meshes.

Comb-like terminals, clusters of straight terminals along midrib impinging at right angles to it; examples, Nos. 9, 11, 15.

Marginal line, a straight continuous vein along the margin; examples, Nos. 6, 21, 22.

Crenated, as generally used.

Looping, a primary bending at the border until it meets the next above it; example, No. 13.

Arching, the contiguous arms of two dividing primaries uniting; ex. No. 15.

Vanishing, as when terminals fade gradually until imperceptible.

Stellate points, seen in the center of meshes after obliteration of terminals; ex. No. 7.

Regular, when the veins run parallel, whether straight or curved; ex. No. 1.

Irregular, when parallelism is mostly absent.

Even, of unvarying caliber; ex. No. 3.

Uneven, the opposite of even; ex. No. 16.

Smooth, having clearly defined, even edges; ex. No. 3.

Blocky, when the meshes are mostly four-sided, squarish or oblong; ex. No. 8.

Polygonal, when the meshes are not blocky, but rounded, few to many-sided; ex. No. 16.

SYNOPSIS.

Group I.— Secondaries regular.

1. S. ALBA, L.— Primaries numerous, close, straight, high-ascending, mostly extending to margin without dividing or branching, forming but a few acute loops towards the apex. Costals intervening, seldom more than one well-developed, often none. Secondaries close, straight, even, conspicuously regular with the exception of a rather frequent forking or imitation of the letter Y. Tertiaries very irregular, uneven, and, as usually observed, forming incomplete meshes owing to partial early obliteration. Except in very young leaves the impression made is therefore of quite regular veining throughout. It is the typical leaf of regularity.— Plate 1, fig. 1.

Illustration is from var. *vitellina*, Koch. The leaves of the typical form of *S. alba* examined showed greater irregularity.

2. S. FRAGILIS, L. — With slight modification the description of *alba* applies to this throughout. The looping is usually more decided, the loops less acute, and there is more curving of the secondaries, and especially of the costals. There is perhaps greater disposition to irregularity. The veins of both are brilliant as they traverse the dense green of the leaf. Of all the species in my list there is, in this pair, the nearest approach to sameness. Since, however, the external characters are different, no difficulty will arise in distinguishing them from each other. *S. lucida*, also, has a near resemblance to both. — Plate 1, fig. 2.

Illustration from vicinity (cult.).

3. S. LUCIDA, Muhl. — Primaries close, regular, curved-ascending, forming towards the apex roundish not very pronounced loops; intervening costals seldom more than one, or none. Secondaries regular, close, curving, often forking or having the Y shape. Tertiaries form irreg-

ular, acute-angular meshes, but are soon partly obliterated. The veining, as a whole, is thin, remarkably smooth and even, very brilliant by transmitted light. — Plate 1, fig. 3.

Illustration from vicinity (cult.).

4. S. PHYLICIFOLIA, L. — Primaries strong, distant, curved-ascending fully to margin, and seldom looping; if so, loops will be weak and close to margin. Costals one to several. Secondaries and tertiaries rather regular, curvy; the latter forming large meshes embracing strong terminals which disappear early; comb-terminals along midrib, seen only in young leaves. Secondaries have the Y fork frequent.

The veining as a whole is somewhat strong, zigzag or wavy, uneven, thickened at junctions. There is absence of sharp angularity. Compare this with *lucida* to note how general sameness of plan with variation of detail results in a markedly different impression produced upon the eye.— Plate 1, fig. 4.

Illustration from specimens from the Arnold Arboretum, originally from Mt. Washington, furnished by Edwin Faxon, Esq.

5. S. ARGYROCARPA, Anders.— Primaries close, zigzag, quite regular, forming from base to tip a more or less regular series of parallel, blunt loops, having seldom any costals intervening. Secondaries usually regular. Tertiaries, merging into terminals, gnarled, not forming definite meshes (in young leaves faint arborescent terminals seen in the background), cause an impression of large reticulation. Along margin some crenate veining.

As a whole the lines of veining appear crooked or wavy, and, though classed as regular, the impression is decidedly different from that of *S. alba*.— Plate 1, fig. 5.

Illustration from specimens from the Arnold Arboretum, originally from Mt. Washington, furnished by Edwin Faxon, Esq.

Group II.— Secondaries partly irregular.

6. S. NIGRA, Marsh. — Primaries distant, straight, or curved-ascending, forming acute loops in lower portion, united at the border by a marginal line in upper; prominent as compared with the rest of the veining. Intervening costals one to several, often extending to marginal line. Secondaries not readily distinguished from the tertiaries, not close, nor generally regular. Tertiaries delicate, forming very minute angular, irregular, definite reticulation. Within each mesh a single very slightly branching stem is seen.

The venation of this leaf is uniformly even, smooth, brilliant, clear, and surpasses all others in the minuteness of its reticulation. At full maturity, the meshes become vacant, retaining, occasionally, simply a stellate point.— Plate 1, fig. 6.

Illustration from specimen of vicinity.

7. S. AMYGDALOIDES, Anders. — The veining of this leaf is best described by comparison with *S. nigra*, to which it bears a very close resemblance. The primaries are closer, having but one or two intervening costals. In the lower half they extend quite to the margin, not forming loops. In the upper half looping is present, gradually merging at the tip into a marginal line. Secondaries stronger, standing out clearly from the tertiaries, mostly regular, closer, straight. Tertiaries, of equal caliber as in *nigra*, usually form a very regular net-work, resulting in larger, squarish, blocky meshes. At maturity there are visible many stellate points in the centers of meshes, — an almost exclusive characteristic pertaining to this leaf. The veining, as in *nigra*, is even, smooth, whitish, brilliant. — Plate 1, fig. 7. Stipule on Pl. 2, fig. 25.

Illustrations from specimen of vicinity.

8. S. ADENOPHYLLA, Hook.— Primaries strong, somewhat distant, simple, or dividing, forming towards the apex

some looping or arching; intervening costals several, short, inconspicuous, curving down to join the preceding primary. Secondaries relatively much weaker, usually quite regular, though with marked exceptions. Tertiaries thin, regular, forming rectangular, blocky, small meshes with scant terminals, or in mature leaf with, simply, occasional stellate points. The forms of the meshes correspond nearly with the different forms of *cordata*, being, however, generally more regular or smaller. The terminals curl so far as the thick texture permits.

Veining, as a whole, is slightly zigzag, somewhat uneven; weak with the exception of the primaries and a few of the secondaries; extends close up to the midrib. The up-curving and parallelism of the secondaries, as in *cordata*, is generally well marked. Veining at apex is *cordata*-like.—Plate 2, fig. 8.

Illustration from specimens furnished by Prof. E. J. Hill, Englewood, Illinois.

9. S. DISCOLOR, Muhl.—Primaries rather distant, curved-ascending, dividing, forming a regular series of arches and sending a strong vein into each tooth. The intervening costals curve down, ranging themselves with the secondaries to meet the primaries. Secondaries regular in part, in which case they are close; frequently quite irregular, broken, more or less zigzag. Tertiaries strong, forming medium-sized meshes in which there is abundant terminal branching. Comb-like terminals along midrib. Obliteration slow. Veining as a whole strong. —Plate 2, fig. 9.

Illustration is from specimens from Lauderdale, Wis., furnished by M. S. Bebb, Esq. Examined also specimens from the vicinity of Ithaca, N. Y., furnished by Prof. L. H. Bailey, Cornell University.

10. S. CORDATA, Muhl.— Primaries, in broad leaves, incline to the horizontal, dividing, the arms forming arches, while tipwards regular loops with round or roundish ends are seen; in narrow forms, looping often prevails throughout; intervals contain one or more costals. Secondaries

mostly regular, strong, usually close, sometimes having the Y fork. Tertiaries strong, regular when subtending regular secondaries, otherwise very irregular, forming meshes of medium size, definite, inclosing distinct, moderately branching terminals, except in young leaves where curling, vanishing terminals may be observed, as in *glaucophylla*. The meshes, therefore, sometimes irregular, angular, but generally oblong, blocky.

As a whole, the venation is zigzag, or broken, thickened at junctions, uneven, exceptionally strong, and no part early obliterated. A character noticeable in several other species, notably in *adenophylla* and *petiolaris*, but specially marked in this, is, secondaries arching upwards in parallel lines.—Plate 2, fig. 10.

S. cordata is a central, typical form, around which cluster *petiolaris*, *sericea*, *discolor*, *adenophylla*, and more distantly, *candida*.

11. S. SERICEA, Marsh.—Primaries strong, distant, curved-ascending, forming often very regular roundish loops throughout. Secondaries sometimes regular, otherwise much broken, weak. Tertiaries not much developed; when present, forming angular, polygonal, medium or small meshes, within which the very delicate flowing terminals are to be observed. Along midrib narrow, deep-green lines, and just outside of these, comb-terminals are to be seen, more or less developed.

With the exception of primaries, the veining is weak. In some forms it is not easy to distinguish from *S. cordata*. Generally, however, the veining has less strength, especially the tertiaries; terminals are more delicate, more profuse, straightening on the borders of large ribs, which is not the case in *cordata*; looping is more regular. While the veining is more irregular, it is in gentler or more graceful lines.—Plate 2, fig. 11.

Illustration from specimens furnished by Prof. L. H. Bailey, of Ithaca, N. Y. Examined specimens also from vicinity of St. Louis.

12. S. PETIOLARIS, Smith.— Resembles *sericea*. Primaries straighter and more ascending; loops less rounded, sometimes very regular. Secondaries closer. Reticulation smaller, more definite, the delicate terminals wanting or only dimly seen in the background, curled.

As a whole, the veining is stronger, especially the tertiaries, and, as in *sericea*, often very irregular. While on the one hand it resembles the latter, on the other, the more regular veined leaves bear a strong resemblance to *cordata*. There is crenate veining along the border.— Plate 2, fig. 12.

Illustration from specimens furnished by M. S. Bebb.

13. S. CANDIDA, Willd. — Primaries numerous, close, straightish but zigzag, forming a very regular series of bluntish or rounded loops well away from the margin, with crenated veining along the border. Intervening costals only occasionally present. Secondaries mostly regular, or nearly so, close, weak. Tertiaries little developed, weak, meshes therefore indefinite; when complete, they are mostly square or oblong, small. Terminals straight. Deep-green borders to midrib as well as along the large veins. Stellate points a few. The veining, excepting primaries, is even throughout. Not closely related to any other.— Plate 2, fig. 13.

The illustration is from vicinity of Lauderdale, Wis. Specimens furnished by M. S. Bebb, Esq. Owing to the peculiar character of the leaf, and, in consequence, the extreme difficulty of rendering it, the representation is a very poor one.

14. S. MYRTILLOIDES, L.— Primaries in smaller leaves close, straight, parallel, forming a very regular series, from base to apex, of rounded firm loops; in larger leaves, curved-ascending, dividing, forming arches; in both, as in *glaucophylla*, there is superimposed a second set of arches, succeeded on their outside along the border by crenate veining,— the best representation of this last character in our list. Costals one or two at intervals. Secondaries about half regular; if regular, close. Both primaries and secondaries strong. Tertiaries irregular, diminishing

from a strong beginning and gradually merging into terminals, forming indefinite, generally large meshes. Terminals, in young leaves, are exceptionally developed, arborescent, curling.

The veining as a whole is nearly even, somewhat zigzag, whitish brilliant. Resembling *glaucophylla* closely, but may be distinguished by the crenate venation, by the extreme regularity of the looping even to the very tip, by the more abundant secondaries, and by the stronger, more enduring terminals.— Plate 1, fig. 14.

Illustration from specimens supplied by Edwin Faxon, Esq., Boston, Mass. Examined specimens from Lauderdale, Wis., by M. S. Bebb, Esq., and herbarium specimens in Missouri Botanical Garden, from different places.

Group III.— Secondaries irregular.

15. S. HUMILIS, Marsh.—Primaries distant, dividing or branching, the arms forming loops, or, most frequently, arches; costals usually several. Secondaries very irregular. The tertiaries, well defined and strong, subdivide the space into large, irregular meshes which inclose remarkably well developed non-curling terminals. Comb-terminals present in young leaves.

As a whole, the venation is exceptionally strong, abundant, in broken, angular, zigzag lines,— the best type of irregular veining in our list.— Plate 3, fig. 15.

Illustration from specimen of vicinity of St. Louis.

16. S. TRISTIS, Ait.— Primaries distant, rather irregular, very zigzag, sometimes dividing, arms forming very wide arches. Secondaries usually irregular. Tertiaries, with exceptions, undeveloped, meshes indefinite or large, embracing faint, fading terminals. The veining, as a whole, very irregular, very uneven and thickened at junctions. In spite of the irregularity there is not usually a sharp angularity in the meshes; they are mostly rounded or polygonal.

Though resembling *S. humilis* in general, the impression made is quite different, chiefly owing to lack of the fine terminals of the latter. There is also absence of comb-like terminals. The veining is much weaker and earlier obliterated. This, with *rostrata* and *purpurea*, are the only ones in which a disposition to irregularity of the primaries obtains.—Plate 3, fig. 16.

Illustration from specimens furnished by Mr. J. Franklin Collins, Providence, R. I. Rendering difficult.

17. S. ROSTRATA, Richardson.— Primaries few, distant, crooked, not parallel, often dividing near their origin, and usually sending a strong vein to each tooth, strong and prominent relatively to the rest of the veining; looping irregular and wanting tipwards; intervening costals numerous, having the same general direction. Secondaries weak, scarcely stronger than the tertiaries, mostly irregular, also markedly zigzag. Tertiaries weak but well defined, forming medium-sized oblong or longish, nearly vacant (in mature leaf) meshes. There remains a background of obscured very delicate terminals. Taking a general survey of the leaf, the minute veining is seen often to assume a crescentic form.

As a whole, the veining is not, as might be expected in such a leaf, very uneven. Compare for example *S. tristis*. Absence of looping at tip causes it to be an exception to an almost universal characteristic.—Plate 3, fig. 17.

Illustration from specimens furnished by M. S. Bebb.

18. S. GLAUCOPHYLLA, Bebb.—Primaries tend to the horizontal in wide leaves, dividing well away from the margin, the arms forming a regular series of arches. There exists besides, usually, a second, smaller set of arches outside the first. Intervening costals usually but one. Secondaries few, seldom regular, changing direction abruptly, broken or zigzag. Tertiaries prominent, constituting most of the veining, very irregular, forming large, polygonal, defined meshes which in mature leaves do not embrace any terminals, save, occasionally, a stellate point.

In very young leaves extremely delicate terminals, finely branching and curling, may be observed.

As a whole, the venation is weak, very irregular, but even and smooth.— Plate 3, fig. 18.

Illustration from herbarium specimen. Fresh leaves, sent by Mr. Bebb, said to be typical, have sub-cordate bases.

19. S. BALSAMIFERA, Barratt. — Primaries strong, nearly horizontal, dividing or branching, forming arches rather irregularly. Costals one or several between two contiguous primaries. Secondaries rather distant, weak, mostly irregular. Tertiaries delicate, dividing a space into irregular, angular or blocky meshes embracing the very delicate, abundant vanishing terminals.

As a whole, the veining is irregular, broken, zigzag, but even and smooth. For so broad a leaf the primaries are uncommonly zigzag. Compared with *glaucophylla*, which it resembles, the veining is weak, with meshes smaller and more permanent. The straightness and angularity of the former is softened in this by the introduction of gentle curves and flowing terminals, giving on the whole a quite different picture.— Plate 3, fig. 19.

Illustration from specimens from the Arnold Arboretum, originally from the White Mts., supplied by Edwin Faxon, Esq.

20. S. PURPUREA, L. — Primaries distant, straight-ascending, somewhat irregular, often dividing or branching; looping not well defined; along margin irregular crenate veining. Secondaries very irregular. Tertiaries defined only in very young leaves, embracing extremely delicate faint terminals,— therefore, in mature leaves, meshes appear large, and veining scant.

On the whole, the venation is weak, even, smooth, flowing or curvy, exhibiting brilliant lines of light, winding amidst the dense green. Peculiar. Impression exceedingly distinct. — Plate 3, fig. 20.

Illustration from specimen from vicinity (cult.).

21. S. BABYLONICA, Tourn.—Primaries regular, straight-

ish until near the border, where ascension is rapid to join the next above, making an acute loop — a more or less straight marginal line resulting from this mode of junction. Secondaries mostly very irregular. Tertiaries strong, forming large meshes mostly polygonal, embracing in young leaves peculiar gnarled terminals which, by obliteration, gradually fade, or, occasionally, leave a central stellate point.— Plate 2, fig. 21.

Veining as a whole uneven as to caliber, broken, brilliant. The impression on the eye is quite peculiar,— say Oriental or Chinese,— where it is said to be native.

22. S. LONGIFOLIA, Muhl.— Primaries strong, distant, straight-ascending to a straight, firm marginal line extending from base to tip. Intervening costals several, often looping more or less completely inwards from the marginal line. Secondaries close, parallel, partially obscured, uneven, forming therefore very indefinite meshes. Tertiaries wanting. The meshes are all longish, blunt at ends, horizontal or ascending, — the long diameters all extending in the one direction.

There is no proper reticulated venation corresponding to anything as seen in other willows. In young leaves, very faint terminals, filling up the background, may be seen. Obliteration early, of all but the principals. Green lines along midrib very distinctly defined. Teeth seldom supplied by any visible veins, — a unique exception to all the rest; in young plants, however, with pinnatifid leaves, the usual rule prevails. As a whole, the veining of this leaf is extremely exceptional.— Plate 3, fig. 22.

Illustration from specimen from vicinity.

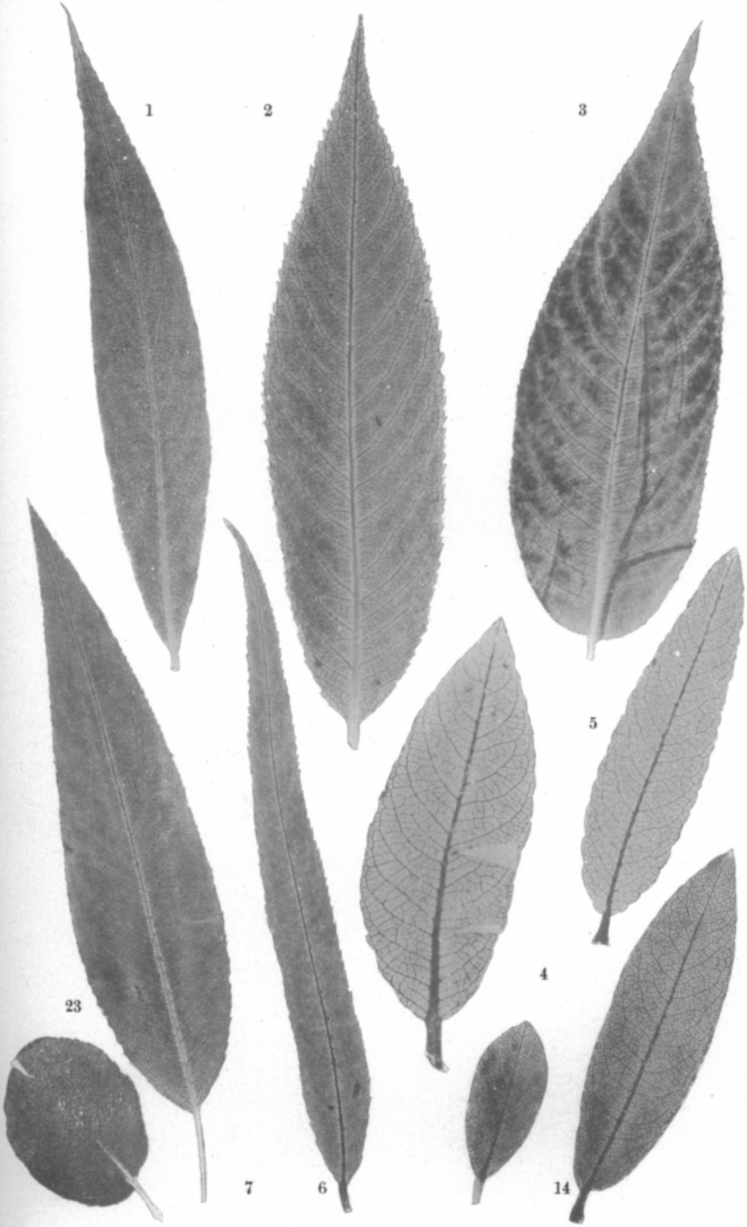
23. S. HERBACEA, L.— Primaries straight, even, high-ascending, partially palmate, dividing and sub-dividing on to the margin. Secondaries scarcely distinguishable from the tertiaries, both irregular, forming medium-sized sharply angular meshes.— Plate 1, fig. 23.

Illustration from Herbarium specimen collected on Mt.

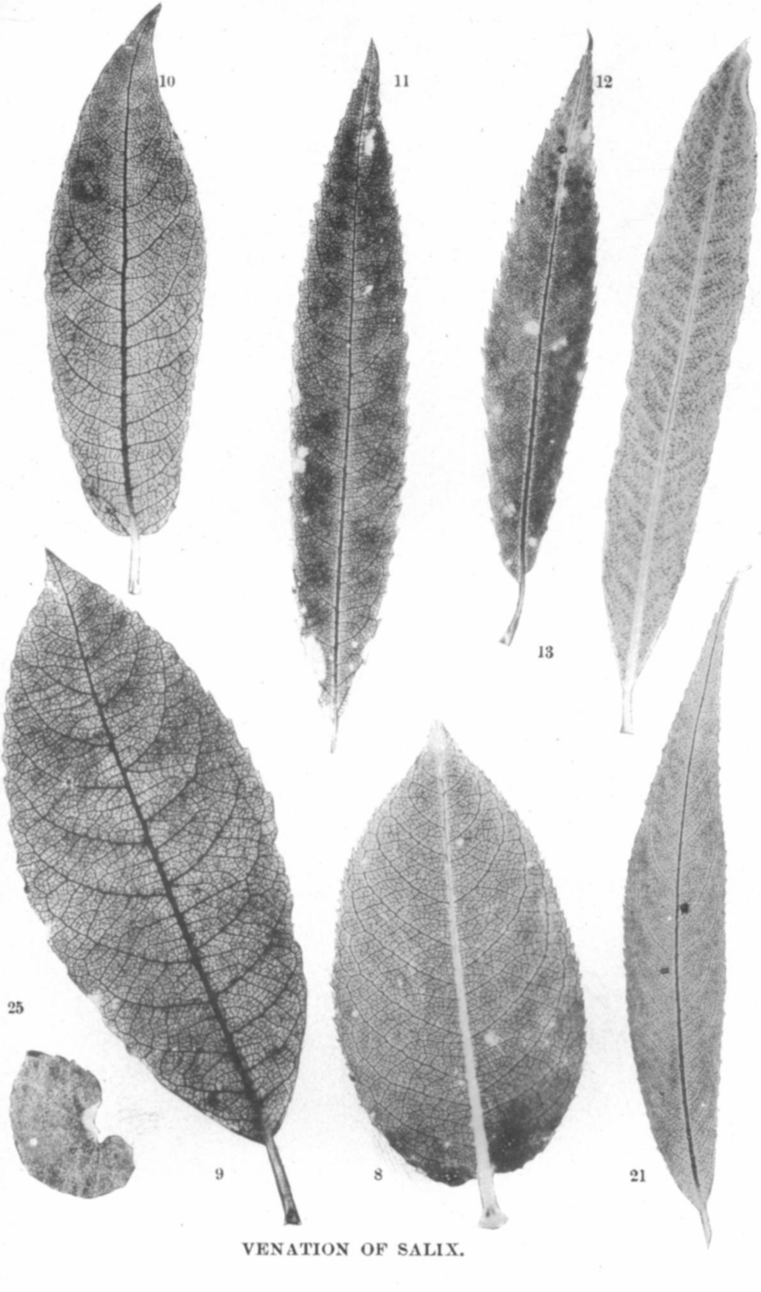
Washington, by Edwin Faxon, and supplied by M. S. Bebb, Esq.

24. S. Uva Ursi, Pursh.— Primaries regular, straight, even, strong, forming a very regular series of rounded loops. Secondaries strong, even, usually irregular, forming large meshes inclosing quite conspicuous terminal branching. Tertiaries wanting.—Plate 3, fig. 24.

Illustration from specimens from the Arnold Arboretum, originally from Mt. Washington, supplied by Edwin Faxon, Esq.



VENATION OF SALIX.



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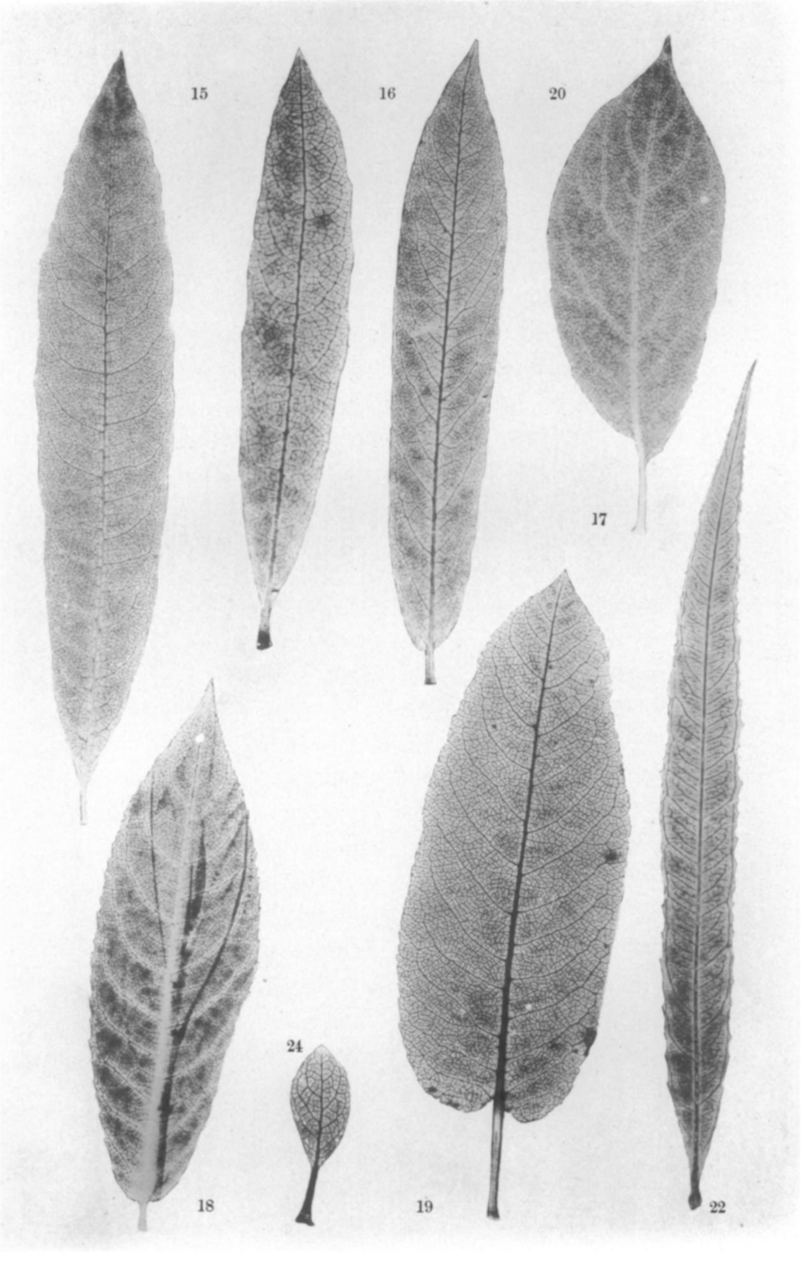

VENATION OF SALIX.